

# ULTRANANOCRYSTALLINE DIAMOND AS HERMETIC AND BIOINERT COATING FOR IMPLANTABLE BIOMEDICAL DEVICES

Xingcheng Xiao, Jian Wang, John A. Carlisle, Orlando Auciello

Materials Science Division, Argonne National Laboratory, 9700 S. Cass Ave. IL 60439 USA

D. Guven, R. Freda, James Weiland and Mike Humayun

University of Southern California, Doheny Eye Institute, Los Angeles, CA 90033 USA

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## Abstract

Diamond is considered as an excellent bio-inert/biocompatible material that can be used for the fabrication of implantable biomedical devices. The main form in which diamond can be applied to the fabrication of implantable biodevices is as thin films. However, the high growth temperature for conventional CVD process used for the synthesis of diamond films has limited its application as a hermetic coating for encapsulation of active implantable microchips for example, to make the Si-based CMOS device bioinert and biocompatible. We demonstrate in this presentation the application of ultrananocrystalline diamond (UNCD) as hermetic coating for encapsulation of implantable biomedical devices such as artificial retina microchips. UNCD coatings are grown in a microwave plasma enhanced chemical vapor deposition (MPECVD) system using a novel Ar-rich/CH<sub>4</sub> plasma chemistry, resulting in films with 3-5 nm grain size and atomically abrupt grain boundaries. The UNCD coatings discussed in this presentation were deposited at substrate temperatures in the 400 - 800 °C range and exhibited a dense and continuous texture demonstrated by cross-section SEM. The electrochemical test in 5% HF proved that these UNCD coatings possess excellent hermeticity although they exhibit a relatively high leakage current in electrochemical tests, due to the relatively high conductivity of plain UNCD films. In order to decrease the leakage current, a series of UNCD coatings were prepared with the addition of different hydrogen content in the plasma (from 1 to 20 %) and at different substrate temperatures. The electrochemical tests were carried out at wide potential range (+5/-5 V) in PBS (phosphate buffered solution). The data revealed that UNCD coatings grown with 1% hydrogen and ~ 400 °C substrate temperature exhibits the lowest leakage current ( $\sim 4 \times 10^{-7}$  A/cm<sup>2</sup> at the potential of +5/-5 V), which satisfies the basic requirements of the encapsulation layer for artificial retina microchips. The mechanisms responsible for increasing the electrochemical inertness of UNCD coatings will be discussed. In this respect, the data suggests that hydrogen incorporation into the grain boundaries saturates dangling bonds making the UNCD coating more insulating and resulting in lower leakage. In addition, *in vivo* tests of bioinertness of UNCD coatings were conducted via implantation of UNCD-coated Si samples into rabbit eyes. All *in vivo* and *in vitro* test results showed that UNCD coatings possess excellent biocompatibility and biostability within the physiological environment. These studies demonstrate that UNCD is a promising candidate as hermetic and bioinert coating for protection of implantable medical devices in biomedical environments.